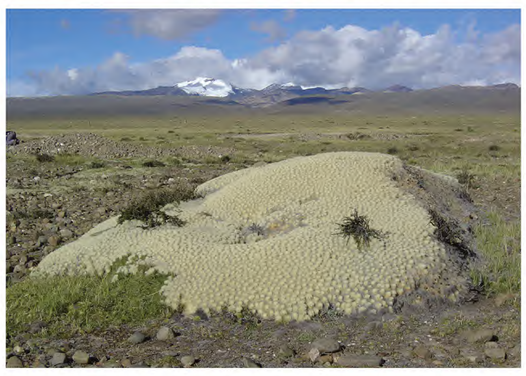
Missouri Botanical Garden

Madidi Project

Plant Diversity and Botanical Discoveries

The Madidi region is a botanical crossroad where elements from the floras **of the Amazon, Andes, the Brazilian shield, and the high plateau of Peru and Bolivia come together and form a mosaic of almost all vegetation types found in Bolivia and beyond.** The original management plan of the Madidi National Park included 1,868 species—about 20% of the species listed for the same area today. The representation of the total flora of Bolivia in the Madidi region is impressive. As a result of more than 70 expeditions and extensive herbarium work done by Garden staff and numerous botanist from around the world, more than 8,500 species of vascular plants and bryophytes have been collected and documented. We estimate that the actual number is between 10,000 and 12,000 species. A catalog of the plants in Bolivia, published in 2014, contains 15,345 species, meaning that 55% of them can be found in the Madidi region alone. In addition, 86% of the plant families and 65% of the genera are present in the area.

Our field and herbarium work has contributed to the discovery of nearly 200 species that were new to science, as well as more than 300 new plant records for Bolivia. The Madidi Project has also identified several rare species previously known only from the type specimen or few collections, thus allowing us to evaluate their threat status following the guidelines of the International Union for Conservation of Nature (IUCN).



Caption: (Top right) The Garden has focused its efforts to collect in remote, virtually unexplored areas, where it is more likely to find new species. The central areas are three to four days' walking distance from the nearest road. This poses logistical challenges, particularly in transportation—motorbikes, canoes, inflatable boats, llamas, mules, and oxen have all been used. (Center right) *Austrocylindropuntia lagopus* is a cactus that is adapted to the extremely harsh conditions of the high plateau of Peru and Bolivia. The Madidi Project was the first to document its presence in Bolivia. (Bottom right) *Cattleya rex*, previously known only from Peru, is now also reported from Bolivia thanks to collections made by Madidi Project staff. (Bottom left) Collecting plants is fundamental to perform more detailed studies and to inform subsequent conservation and management efforts. The Madidi Project has made more than 52,000 botanical collections.

Providing Basic Information

The Madidi Project has made numerous quantitative inventories in forests and grasslands. The purpose is to document the composition and structure of different types of vegetation and to study biological patterns at different scales. The data set consists of 750 inventories and more than 2.4 million observations of more than 200,000 trees and countless herbaceous plants. Such inventories generate taxonomic problems because not all collections can be identified to species. However, we have made a uniform taxonomy of close to 3,000 tree species. This quantitative inventory covers most of the elevational gradient and nearly all vegetation formations and climates in the region. It has become one of the most elaborate and comprehensive tree inventories in the Neotropics.

The project's data represents a unique opportunity to study what factors influence the distribution of diversity and of plant species, allowing us to test numerous biological and ecological hypotheses and monitor changes in plant species and communities in relation to global warming. Studies indicate, for example, that while the spatial extent of the niches of the Amazonian tree species is larger, they are more sensitive to changes in climate than the Andean species. Since they are adapted to constant wet conditions, their survival during the increasing droughts predicted in the Amazon due to global warming will be dramatically affected.

The Madidi Project has produced one of the most elaborate and comprehensive tree inventories in the Neotropics.

Caption: (Top) Measuring the diameter of a tree in a permanent plot. (Bottom) Measuring functional characters in the field, a relatively recent approach initiated to understand the function of the forests.

Madidi National Park

The Madidi National Park is located in the northwestern part of Bolivia. It was created in 1995 thanks in great part to a biological rapid assessment report (RAP) written by Missouri Botanical Garden Curator Alwyn Gentry, Ted Parker, Robin Foster, and Louise Emmons. It is one of the most species-rich protected areas on Earth. The high levels of biodiversity are undoubtedly a result of its location within the tropics. It contains ample representation of both the megadiverse Andean and Amazonian floras; high environmental heterogeneity due to the impressive elevational relief of 200 to 5,760 m; large variation in precipitation schemes; and well-preserved ecosystems. At nearly 20,000 km^2, Madidi displays an impressive series of vegetation types—from lowland rain forest and Amazonian savannas to montane dry and wet forests and remnants of *Polylepis* forests and high Andean grasslands.

The area is threatened by the construction of hydroelectric dams and roads; mining; exploration for gas and oil; colonization; expansion of the agricultural frontier; and the extraction of timber. Some of these threats are ongoing while others are still in the planning phase. The Garden's goal is to provide land managers, policy makers, and other stakeholders with detailed information on the area's plants to minimize and mitigate any negative effects these threats have and to aid in the conservation of the area.

The Garden started the Madidi Project in 2001 to make a botanical inventory of the Madidi National Park and surrounding areas, tackling an area of close to 100,000 km^2 (the size of Indiana). The main goals of the project are to discover and document the species of vascular plants and mosses; to quantify and classify the vegetation types; to educate a new cadre of Bolivian botanists; and to inform the general public as well as decision makers about the wonders and continued need for conservation of this magnificent place.

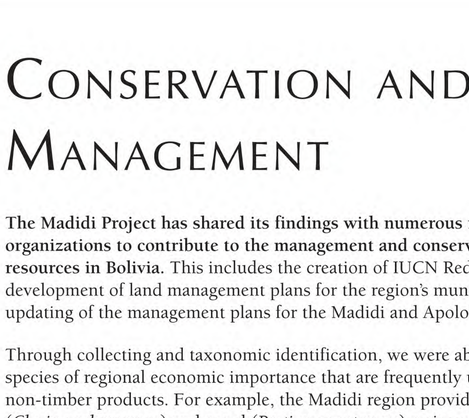
Caption: Pre-Andean Amazonian forest near the Strait of Bala. This is one of the main entrances to the Madidi National Park.

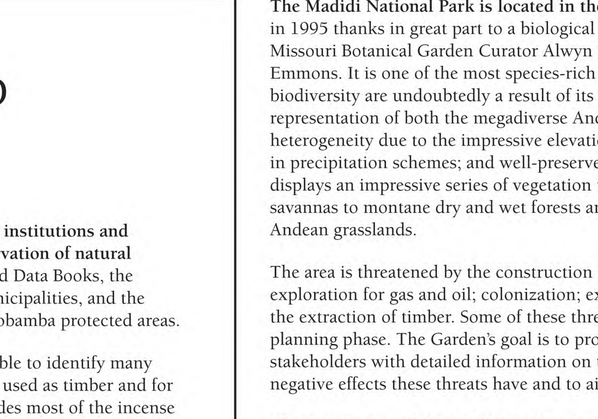
Conservation and Management

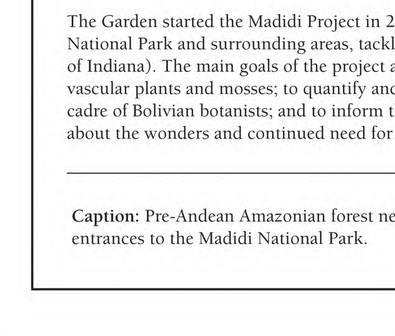
The Madidi Project has shared its findings with numerous institutions and organizations to contribute to the management and conservation of natural resources in Bolivia. This includes the creation of IUCN Red Data Books, the development of land management plans for the region's municipalities, and the updating of the management plans for the Madidi and Apolobamba protected areas.

Through collecting and taxonomic identification, we were able to identify many species of regional economic importance that are frequently used as timber and for non-timber products. For example, the Madidi region provides most of the incense (*Clusia pachamamae*) and copal (*Protium montanum*) resins used in Bolivia, both widely used in Catholic and traditional religious ceremonies. Prior to the Madidi Project's studies, the identity of both species remained uncertain. The incense (*C. pachamamae*), which has been used for almost 500 years, turned out to be a new species. It was described in the Missouri Botanical Garden's journal *Novon* in 2008. Other project publications and data have also supported the management plans for the sustainable harvesting of this plant's resins.

Conservation also depends on the buy-in from the local people who live in and near these protected areas. Over the years, we have built a close relationship with the communities of indigenous people and farmers living in the region. Many are interested in working opportunities helping us collect plants and perform quantitative inventories. Project publications and presentations are then shared with the communities as learning tools to help them understand the importance of maintaining the protected areas and of sustainable management and use of the forest and its species.







Caption: (Top left) Five species, or half of the known species in Bolivia, of the Andean bamboo genus *Aulonemia* have been described in recent years from collections made through the Madidi Project. The inhabitants of the region harvest the stems to manufacture traditional musical wind instruments. However, little is known about their ecology, distribution, and IUCN status. Most of the species are known only from the type specimen, so it is highly likely that they are threatened. (Top right) The collection of the copal resin (from *Protium montanum*) contributes to the cash income for the communities and, if sustainably managed, to the conservation of forests in the Madidi region. (Bottom) In the "witches market" in La Paz, vendors sell copal and incense resins.

Education and Capacity Building

The Madidi Project actively trains young Bolivian botanists by reinforcing the capacities of its researchers or by supporting and guiding thesis work. Through the years, we have supported 48 undergraduate students and four master's degree and doctoral students. We have made numerous presentations of our research at numerous scientific gatherings where we have presented our results. In addition, we have taken advantage of the project's activities both in the field and in the herbarium to train more than 60 volunteers—from junior professionals to pre-graduation students. We also give frequent lectures or workshops to biology students at the university in La Paz.

In addition to training, we promote science, botany, and conservation to the general public in "information fairs" that the municipality of La Paz supports and promotes. We also work to raise awareness about the importance of the Madidi National Park by interacting with the local communities and sharing the project's activities and findings through press releases and online through social media and our website www.mobot.org/madidi.

The Madidi Project has supported the work of 48 thesis students and the training of 69 volunteers and 150 guides

Caption: (Top) Project staff constantly participate in the training of students both in field practices and in the use of digital tools for taxonomic studies in the herbarium. (Bottom right) Presenting research at a popular information fair in La Paz. The municipality is unique in that it supports and promotes "information fairs" targeting the general public. (Bottom left) The Madidi Project actively disseminates the results of its research through participation in national and international scientific conferences.

Text by Alfredo Fuentes and Peter M. Jørgensen.

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Science and Conservation at the Missouri Botanical Garden

With operations in over 35 countries around the globe, the Missouri Botanical Garden collaborates with local institutions wherever Garden botanists conduct research and field work, providing technical expertise, assistance with fundraising, and better communication with the worldwide scientific community.

The research division consists of 50 Ph.D. botanists assisted by 144 support staff and 20 graduate students. Studies concentrate on the plants of Meso- and South America, sub-Saharan Africa, Madagascar, China, and North America.

Individual Garden scientists are specialists in the plants of particular regions, in the systematics and evaluation of major plant families, and in the interactions between plants and people.

The Garden serves as the headquarters for several major collaborative publications, such as *Flora of North America* and *Flora Mesoamericana.*

For more information, visit
www.mobot.org/plantscience

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1. EUTERPE longevaginata 2. MAXIMILIANA regia 3. DIPLOTHEMIUM Torallyi.

Alcide Charles Victor Marie Dessalines d'Orbigny traveled extensively in South America between 1826 and 1833. He was a geologist and is widely considered the father of micropaleontology. He collected extensively, and his collections and illustrations of palms from Paraguay and Bolivia were the basis for Carl Friedrich Philipp von Martius's description of palms in d'Orbigny's monumental work *Voyage dans l'Amérique méridionale*. The three species illustrated have all undergone name changes since their description in 1847. *Euterpe longevaginata* is now a synonym of *Euterpe precatoria,* also described by Martius in the same book. *Maximiliana regia* is today considered a synonym of *Attalea maripa*, and both species are found in the Madidi National Park. *Diplothemium torallyi* is an endemic threatened species from the dry valleys of Bolivia, currently placed in the genus *Parajubaea*. It grows slowly and its habitat is restricted to about 1000 km^2. The areas where it occurs are severely fragmented and under continued pressure from land use changes.

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